Saving Venice

One of the world's most iconic cities is under threat from rising seawater. With climate change fuelling the sense of urgency, engineers are constructing the world's most advanced flood barrier on the floor of the Venice lagoon. Its ingenuity? When not in operation, you wouldn't even know this €5.5bn construction was there.

TEXT: **CLAUDIA B. FLISI** PHOTOS: **MAURIZIO CAMAGNA**

The year 1966 was a wake-up call for the city of Venice. Until then, centuries of intermittent acqua alta (high water) had been an annoyance in the winter months, but not a major threat. Every three years or so, a combination of high tide and weather conditions resulted in water on some city streets that lasted for a few hours; rubber boots and raised platforms handled the problem.

BUT THE FLOODS of 1966 brought two metres of water into Venice, causing millions of dollars in damage and destroying priceless artwork. Over the next 40 years, climate change, rising sea levels, and a sinking city have increased the frequency of acqua alta and brought urgency to the need for a solution. "We can't predict the future, but we know things have become verifiably worse in recent years," notes local architect Monica Ambrosini.

She is a spokesperson for Consorzio Venezia Nuova the consortium entrusted by the Italian government to save Venice from the sea. That solution is Mose, an innovative flood barrier project designed to control the high tides threatening the city. The name alludes to the biblical leader who is said to have parted the Red Sea, and stands for MOdulo Sperimentale Elettromeccanico, or Experimental Electromechanical Module.

Mose is a system of 78 mobile gates placed at the three openings of the barrier island separating the Venice lagoon from the Adriatic. Under normal circumstances, they will lie flat under the water in boxy structures, or caissons. When needed (an estimated four or five times a year), they will be raised to prevent rising sea levels from entering the lagoon. When the high tide has subsided, they will be lowered again.

Monica Ambrosini: 'Things have become verifiably worse in recent years.'

THIS IS THE key to Mose's ingenuity. Unlike water control systems in Rotterdam, London, and a number of Japanese cities, Mose does not have permanently visible pillars. One of the design requirements was for it to blend in with the city it defends, and this called for a system as unique as Venice itself.

When the go-ahead for construction was first given in 2003, Mose was "the most innovative system of its kind," says Ambrosini, and "it still is. It is very flexible at all tide levels. Its operation is quiet. It is respectful of marine life and the environment."

ENVIRONMENTAL CONCERNS ARE a top priority because of the city's World Heritage status and because of the 23 million tourists who visit Venice each year. Increasing numbers of them come on mammoth cruise ships, so Mose had to accommodate these cruise vessels, and oil tankers as well.

The technical challenges of the project have been compounded by its size and

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> MONICA AMBROSINI, CONSORZIO VENEZIA NUOVA

MOSE: **PROJECT IN FIGURES**

- **1 lock for big ships** (at Malamocco)
- **2 refuge harbours** (at Lido and Chioggia)
- **3 metre-high** tide can be withstood
- **4 mobile barriers**
- **15 minutes** average time to close (lower) the barriers
- **30 minutes** to open (raise) the barriers
- **78 mobile** barriers in total
- **1,000 workers** involved
- **2018** estimated year of completion
- **€5.5bn** estimated total cost (as of March 2016)

DAM IT: **some other notable flood barriers**

The Oostersheldekering (The Netherlands)

The 9km-long Oosterscheldekering is the largest surge barrier in the world, and is just one of 13 dams and storm surge barriers in the Delta Work project in the Netherlands. The Oosterscheldekering consists of a large number of doors located at sea level that regulate the amount of water flowing in from the North Sea. The dam has only been fully closed 25 times since it was officially opened in 1986.

Thames Barrier (United Kingdom)

The Thames Barrier is the world’s second largest movable flood barrier and, since completion in 1982, it has protected London from being flooded by exceptionally high tides and storm surges moving up from the North Sea. It consists of rotating gates that, when open, lie horizontally on the bottom of the Thames and, when closed, rotate into a vertical position. As of 2016, it had been closed 176 times.

Saint Petersburg Dam (Russia)

In 1978, the Soviet Union started the construction of the Saint Petersburg Dam, but the 25km-long complex of dams was not completed until 2011. It consists of 11 dams and two water locks that separate the Gulf of Finland from Neva Bay in order to protect the city from coastal flooding. The heart of the Saint Petersburg dam is the southern water-lock and its two floating radial steel gates that swing in to meet in the middle.

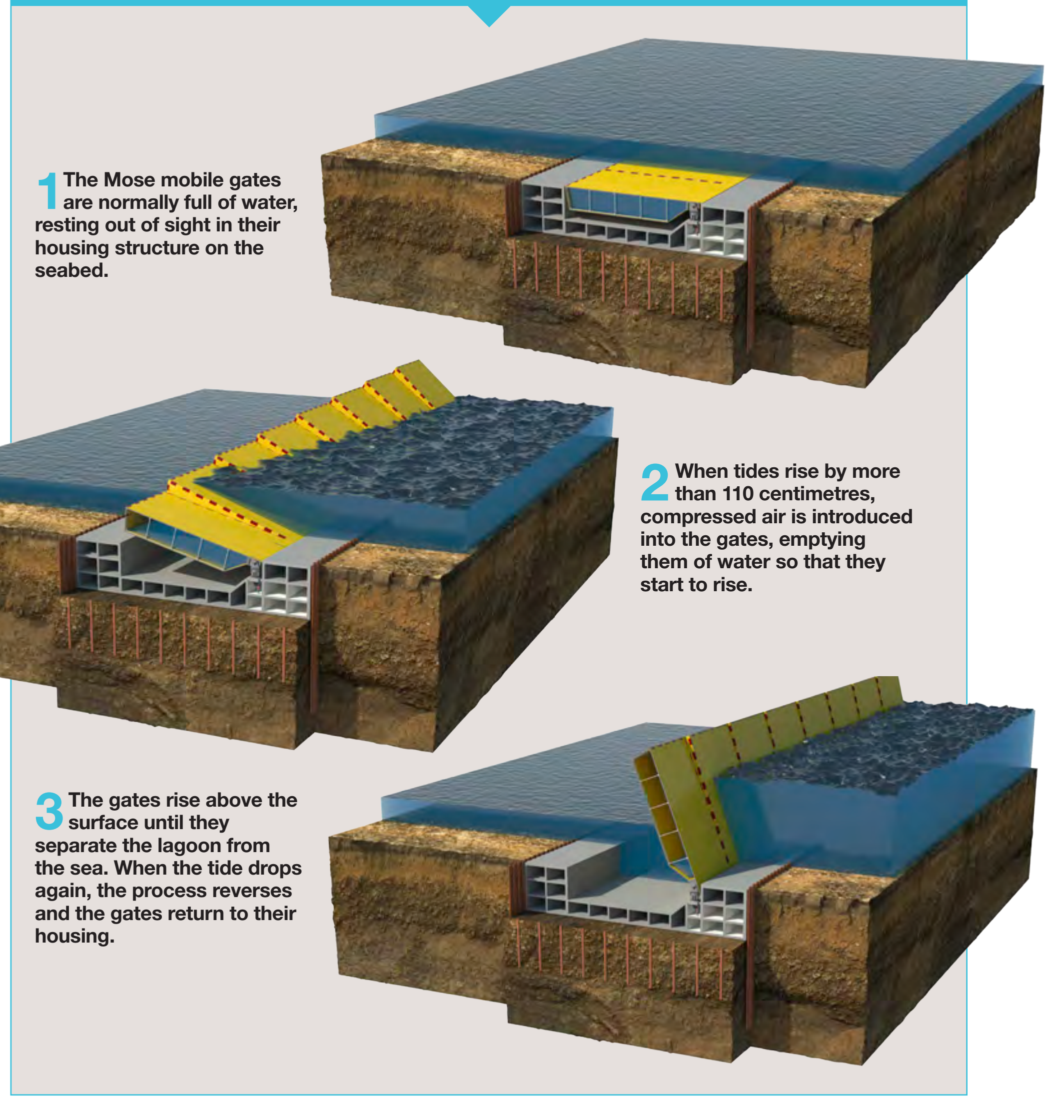
complexity. Engineer Tomaso Gastaldi works for Comar Scarl a company performing contracting services for Mose overseeing the work of 50 or more companies, including four major enterprises. "The problem with any large project is coordination of a large number of suppliers and companies," he says. "You have to integrate different deadlines and coordinate the activities of many companies. Each company has its own interest and know-how, and not all are collaborative in the same way. This is the major issue we deal with."

IN ADDITION, MOSE has been embroiled in political scandal and its deadlines have been delayed several times by corruption charges.

The juicy headlines have obscured the project's solid accomplishments, according to Gastaldi and Ambrosini. First and foremost, Mose will protect Venice from up to three metres of acqua alta, and it will do so in a way that is sensitive to its environment. Second, its unique technology will encourage the development of engineering innovations – civil, mechanical, and marine. Plus, if in the future it is decided that Mose should be dismantled, this can be done without permanent damage.

One of Mose's barriers has been operating in test mode since May 26, 2016, and the technical performance has been more than satisfactory. All 78 gates will be officially operational in June 2018. ■

HOW IT WORKS



Compact, quiet and energy efficient:
Alfa Laval's cooling solution

When flooding conditions occur, Mose's 78 mobile gates are pumped with compressed cooled air from Alfa Laval heat exchangers. This air forces out the seawater that normally fills the gates – and keeps them submerged – and they rise from their caissons under the lagoon to become barriers against rising sea levels. The air has to be cooled first because the mobile gates are made of a rigid composite material that cannot tolerate air at too high a temperature, explains Paolo Zapparoli, Product Manager, Industrial Dry Coolers, at Alfa Laval in Alonte, Italy.

Two models of Alfa Laval air heat exchangers are being used in the Mose project.

From the same Alfa V product family – they differ only in size and their heat transfer capability – they were chosen for their compact layout, low noise level, and energy efficiency, says Zapparoli.

He adds that another important element in this project's success was the collaboration between Mose engineers and Alfa Laval specialists: "We worked together from the start to adapt our standard models to their specific requirements, suggesting improvements in terms of materials and new technologies."

These modifications included thermic material, a new interface, decreased sound levels thanks to new ventilation, adjusted mechanics, an improved layout, lowered electrical consumption, reduced footprint, and compressors with high power and low volume.

The underlying reason for the modifications was that several years had passed since the first discussions of the project to the actual realisation, and during this time technology had not stood still. Zapparoli is very proud of this aspect of the collaboration — that Alfa Laval had taken the initiative to incorporate newer technologies, even though the brief had been based on older ones.

The system has been tested successfully in a pilot project on site. Project engineers have made a few technical adjustments to improve the automation of the barriers, but the components have performed impeccably.